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Robert D. Moser

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University of Illinois at Urbana-Champaign  
Department of Theoretical and Applied Mechanics  
216 Talbot Laboratory  
104 S. Wright St.  
Urbana Illinois 61801

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13. ABSTRACT (Maximum 200 words)

The funds from the subject grant and the matching funds from the University of Illinois were used to purchase the equipment listed in tile table from the indicated vendors. As pro-posed, this equipment includes PIV data acquisition equipment (items 1-7) and computing equipment (items 8-19) used in experimental data analysis and numerical simulation. Also included are several added items to enable improved performance on the primary missions of the facility. These include a high speed (100 Mbit/sec) switch card for the in building net-work (item 16 for improved and isolated data transfer from the fluids lab to the computing facility) and a 144Gbyte RAID disk array (items 14 and 15 for high-speed and high capacity disk I/O for post-processing data analysis). The primary computing platform was selected to be a 5 node, 20 processor IBM SP system with a total of 12 Gigabytes of memory. Through a series of benchmarks using turbulence simulation codes, it was determined that the selected IBM system was superior in cost/performance to the proposed SGI system, or SGI's current offereing, for the applications of interest. The architecture is also more advantageous for use as a real-time PIV data analysis system, though it is marginally less convenient for large scale simulation. For these reasons the IBM system was selected over the originally proposed 16 processor SGI system.

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# Facility for Integrated Experimental and Computational Turbulence Research

Final Report on AFOSR DURIP Grant F49620-99-1-0175

By R. D. Moser & R. J. Adrian

Department of Theoretical and Applied Mechanics  
University of Illinois at Urbana-Champaign

The funds from the subject grant and the matching funds from the University of Illinois were used to purchase the equipment listed in the table from the indicated vendors. As proposed, this equipment includes PIV data acquisition equipment (items 1-7) and computing equipment (items 8-19) used in experimental data analysis and numerical simulation. Also included are several added items to enable improved performance on the primary missions of the facility. These include a high speed (100 Mbit/sec) switch card for the in building network (item 16 for improved and isolated data transfer from the fluids lab to the computing facility) and a 144Gbyte RAID disk array (items 14 and 15 for high-speed and high capacity disk I/O for post-processing data analysis).

The primary computing platform was selected to be a 5 node, 20 processor IBM SP system with a total of 12 Gigabytes of memory. Through a series of benchmarks using turbulence simulation codes, it was determined that the selected IBM system was superior in cost/performance to the proposed SGI system, or SGI's current offereing, for the applications of interest. The architecture is also more advantageous for use as a real-time PIV data analysis system, though it is marginally less convenient for large scale simulation. For these reasons the IBM system was selected over the originally proposed 16 processor SGI system.

The computing and laboratory equipment is now being heavily utilized by 12 students and staff members of the Laboratory for Turbulent and Complex Flows. There are several research activities being pursued using this new equipment. First, it is being used to acquire and analyses PIV data of turbulent flows. The facility allows an unprecedented large number of PIV velocity fields to be measured and analyzed, allowing very reliable statistics to be gathered. For example, the two-dimensional two-point correlation determined from 3500 fields was used to compute a stochastic estimate of the velocity, which is shown in the attached figure. The large number of independent fields allowed the converged statistics required to reveal the train of "weak" vortices lined up diagonally from the "strong" event vortex. This has not been possible before. This experimental data acquisition is being pursued primarily in support of our "Optimal LES" research.

The second use of the equipment is in performing Large Eddy Simulations (LES) and small direct numerical simulations. For example, optimal LES models have been implemented and tested on the SP system. Results from such tests have allowed very accurate Optimal LES models to be developed. Finally, the SP system is being used for extensive

data analysis, both in support of the optimal LES development and other projects, such as the analysis of compressible shear layers.

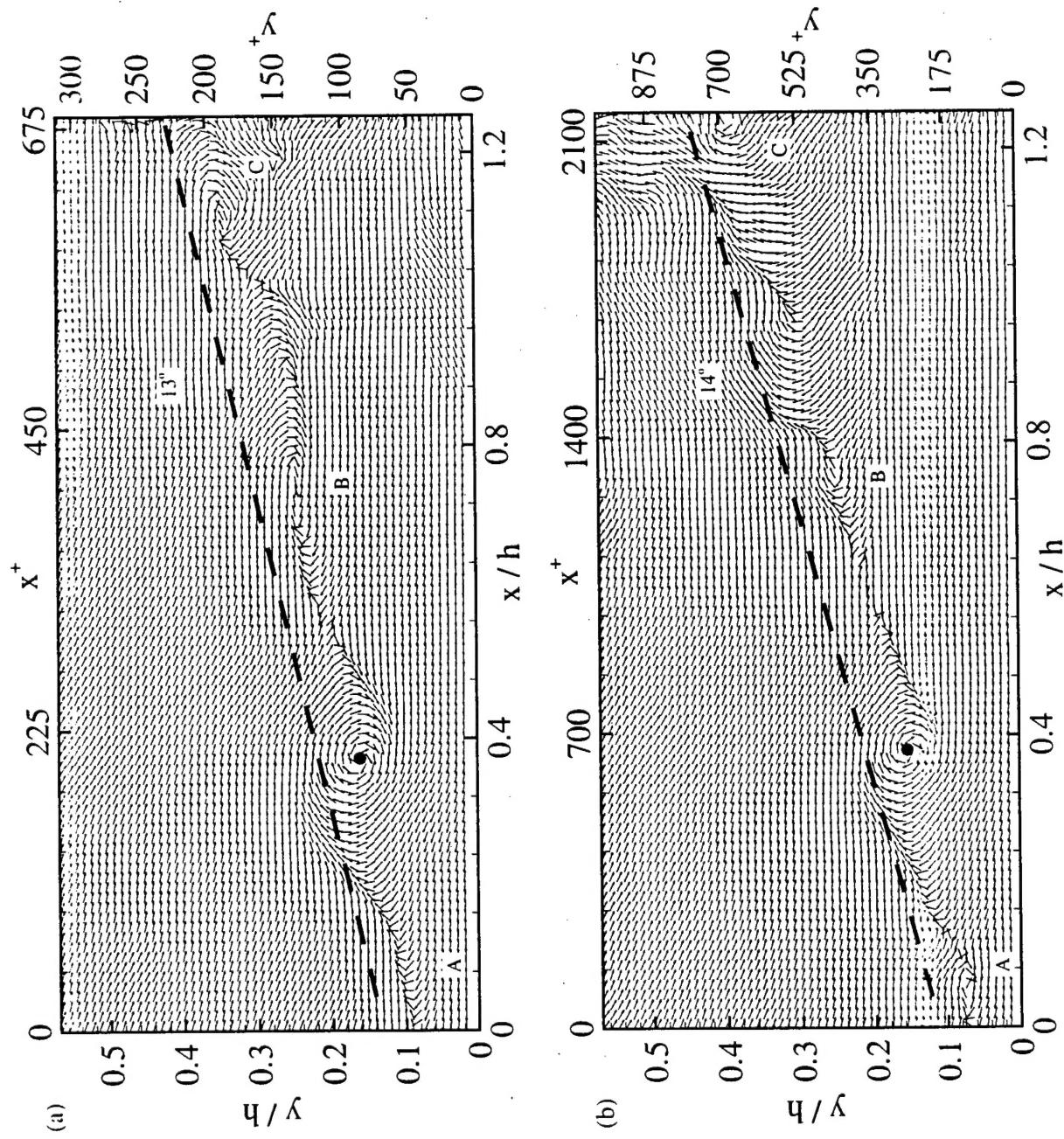
The primary research projects for which the purchased equipment has been used are "Towards Optimum Formulations of Large Eddy Simulation of Turbulence," jointly funded by NSF and AFOSR under grant NSF-CTS-9616219, "Optimal Large Eddy Simulation of Turbulence" funded by NSF under grant NSF-CTS-0001435, and "Weakly Compressible Descriptions of Turbulence in Compressible Flows," funded by AFOSR under grant F49620-97-1-0089.

Item	Quantity	Description	Vendor	Cost
1	4	New Wave Gemini PIV Lasers	New Wave	146,271
2	2	TSI LaserPulse Synchronizers	TSI Inc.	21,800
3	4	High Speed Camera interfaces	TSI Inc.	20,000
4	4	Dual-frame PIV Cameras	TSI Inc.	40,000
5	2	Dual Pentium Laboratory Computers	TSI Inc.	12,400
6	2	TSI Insight PIV Image Capture Software	TSI Inc.	16,000
7	2	Scheimpflug Camera Mounts	TSI Inc.	2,100
8	1	5 node/20 processor IBM SP computer with 12Gbyte memory	Solution Tech.	323,497
9	1	IBM RS/6000 Workstation	Solution Tech.	6,231
10	1	IBM L06 Tape Library	Solution Tech.	23,946
12	120	IBM XL Data Cartridges	Solution Tech.	5,554
13	1	IBM PCI Dual Channel SCSI Adapter	Solution Tech.	247
11	1	IBM Maintenance/ Extended Warranty for IBM equipment (2 years)	Solution Tech.	36,540
14	1	JetStor II, LVD RAID Device	AC&NC	3,850
15	4	Seagate 36Gbyte Hard Drives	Computers4 Sure	2,982
16	1	CISCO 24 port 100Mbit Switch Card	CCSO	3496
17	1	IBM AIX and SP software license	CCSO	4,400
18	1	IBM Storix software	Solution Tech.	2,390
19	1	MatLab Software and License	CCSO	774
		Total		672,478

Table 1: Table of Equipment purchased under the subject DURIP Grant. The vendor abbreviations are: "New Wave" for "New Wave Lasers," "Solution Tech." for "Solution Technologies Inc.," "AC&NC" for "Advanced Computer and Network Corporation", "CCSO" for equipment and licenses purchased through the University of Illinois Computer and Communication Services Office.

Source of Funds	Amount
AFOSR DURIP Grant	360,000
University of Illinois Matching Funds	299,500
Ford Motor Co. Gift	5,615
NSF Grant CTS96-16219	5,615
Departmental Computer Funds	1,748
Total	672,478

Table 2: Sources of funds for the equipment listed in Table 1. The Ford and NSF funds contributed to the purchase of the laboratory equipment (items 2-7 in Table 1). The departmental funds contributed to the CISCO switch card (item 16 in Table 1).



Linear stochastic estimation of  $\langle u_i(\mathbf{x}) | \lambda_{ci}(\mathbf{x}) \rangle$  at (a)  $Re_t = 547$  and (b)  $Re_t = 1734$  in turbulent channel flow. The hairpin packet structures evident in instantaneous velocity realizations of wall turbulence are so dominant and persistent that they leave a clear footprint upon the statistics of the flow as is indicated above. 3500 independent velocity realizations at each  $Re_t$  were used to compute the two-point correlation functions used in the stochastic estimation.